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Particulars of the Maps of Cambodia and Cochín-China executed by French Government Surveyors, with information as to where they may be obtained.

Basse Cochín-Chine et Camboge. Carte Générale. Résumant l'ensemble des travaux exécutés par ordre de M. le Vice-Amiral Charmer en 1861 et M. l'Amiral Bonard en 1862. Par MM. Manen, Videlin et Heraud, Sous-Ingénieurs Hydrographes de la Marine. Publié par ordre de l'Empereur sous le Ministère de M. le Comte P. de Chasseloup-Laubat, Sénateur, &c. Au Dépôt-Général de la Marine en 1863.

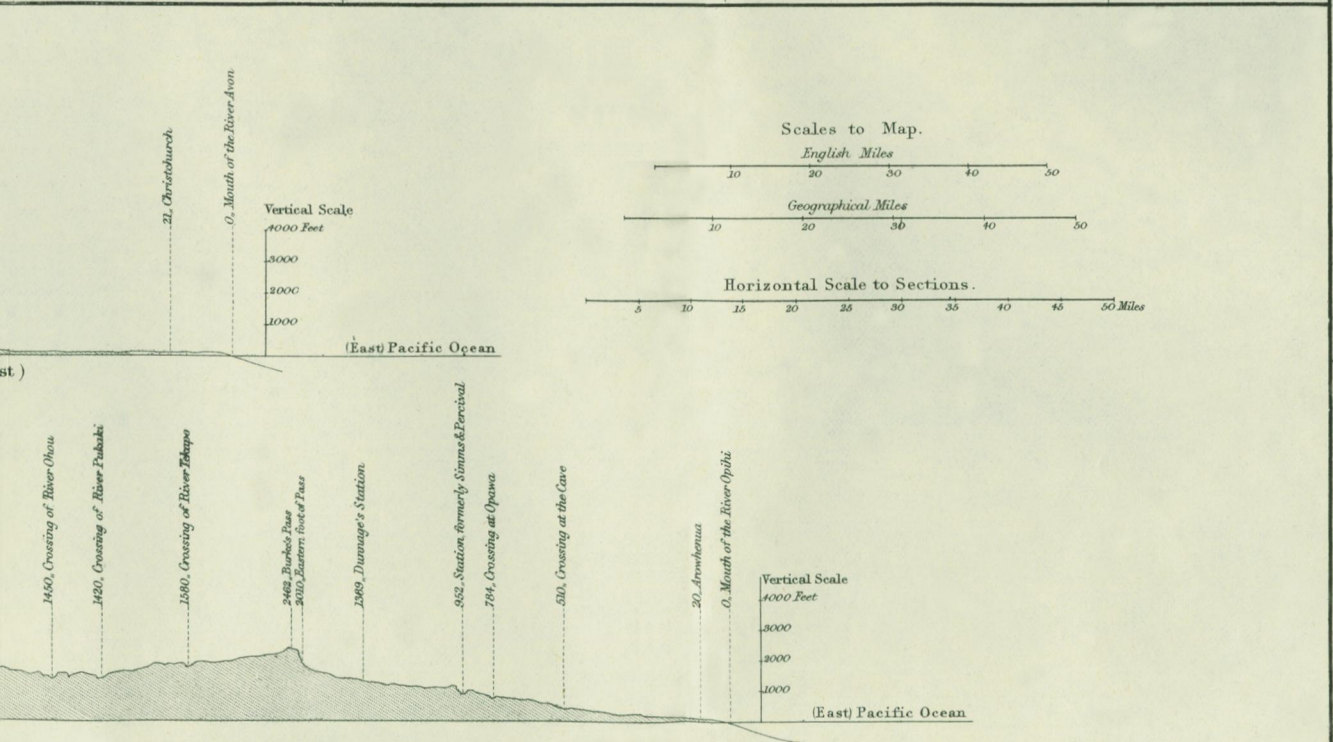
To be had in four sheets, probably in eight also.

XVI.—*Altitude Sections of the principal Routes between the East and West Coasts of the Province of Canterbury, New Zealand, across the Southern Alps.* By JULIUS HAAST, PH. D., F.G.S., F.L.S., &c.

No better insight into the structure of a country can be offered to the physical geographer than carefully prepared altitude sections, extending in various directions, and sufficiently numerous to afford opportunities for comparison. I thought, therefore, that in laying the accompanying sections and maps before the Society I might thereby contribute a share towards the better knowledge of the structure of this island, which has been again brought so prominently before the public, since the opening up of the mineral resources at the west coast.

When the rush to those gold-fields began to assume such dimensions that thousands of persons started overland from Otago and Canterbury, and the other neighbouring provinces, to this new Eldorado, one pass alone was known, namely, that by the Hurunui and Teramakau, over which a bridle-path, cut through the bush at the worst places, led to the west coast.

As this route was considered to be rather circuitous, several parties were sent out by the Provincial Government of Canterbury to find if possible other passes near the head-waters of the Waimakariri and Rakaia. From this resulted the discovery of Arthur Pass, near the head-water of the Waimakariri by Messrs. Arthur and George Dobson, and of the so-called North Rakaia Pass by Messrs. Browning and Griffiths. You are well aware that a pass had been discovered previously by myself near the head-waters of Lake Wanaka, leading into Open Bay, and another by the late Mr. H. Whitcombe near the glacier-sources of the Rakaia and Hokitika Rivers. In both these cases the western rivers were followed to the sea-coast; but the discovery of the latter route resulted in the death of the talented and



energetic engineer Henry Whitcombe, who was drowned at the mouth of the Teramakau, when close to a Government dépôt at the River Grey.

The route by Arthur Pass was selected by the provincial engineer as it was not only the most central, but also, considering the rugged character of our Alpine ranges, because it presented less difficulties than any of the others.

Each route had, however, its advocates in the public press and in the legislative assembly, and as there was no time to make altitude sections by astronomical observations, or even by means of the spirit-level, I was instructed by the Provincial Government to prepare them by barometric observations. I already possessed the necessary material for such a purpose, which I obtained on previous journeys between the east and west coasts by Harper Pass, or the Teramakau and Hurunui rivers, and by Haast Pass, or the Makarora and Haast rivers. I started, therefore, in the spring of last year (October, 1865), furnished with a set of three good aneroid barometers by Negretti and Zambra, and other necessary instruments, and took a series of altitude observations by the Waimakariri over Arthur Pass, down the Otira and Teramakau rivers to the west coast, returning by the Hokitika River and its tributary the Styx thence across a saddle at its head, descending into the Arahura River, which brought me to Browning, or the north Rakaia Pass. After crossing this pass, still covered deeply with snow, I returned by the Wilberforce and Rakaia to Christchurch, and prepared immediately after my arrival the four altitude sections.

Since then I had an opportunity to visit also Whitcombe Pass, and collected all the necessary data for the fifth section, which I added to the others, so as to complete the five routes across the central chain in this province.

It will be observed that I have fixed upon the highest point reached by each route on crossing the central chain, as a starting point to both coasts, as by so doing not only the distance of that particular point from the east and west coasts is clearly shown, but also the comparative lengths of road to be traversed, as well as their principal characteristics compared one with another.

In the table overleaf I have given all the principal numerical statistics of these different routes, namely, their total length, and the distance from the summit of the passes to the east and the west coasts, which, for comparison, is not without interest.

The shortest route to the west coast is therefore by the Rakaia and Wilberforce, over Browning Pass, thence down the Arahura and Styx rivers to Hokitika. This is only 134 miles; whilst the longest is that which starts from the east coast, near Arowherma, and passes by Lake Wanaka, across Haast Pass, and measures

226 miles. But the routes by Arthur and Harper Passes will always be preferred by travellers, as they are seldom obstructed by snow, and are not subject to avalanches.

Routes between the East and West Coasts of the Province of Canterbury.*	Altitude of Saddle or Pass in Central Chain, in feet.	Total Length, in miles.	Length from Summit of Pass to East Coast.	Length from Summit of Pass to West Coast.
Rakaia:—				
Wilberforce route by Browning } Pass† }	4645	134	103½	30½
Whitcombe's route by Whitcombe } Pass }	4212	147½	107½	40
Waimakariri:—				
Route by Arthur Pass	3038	148½	101	47½
Hurunui:—				
Route by Harper Pass	3008	146	102	44
Wanaka:—				
Route by Haast Pass	1716	226	182	44

A glance at the different sections and the preceding table will show at once that the western slopes of the central chain are by far the steepest, and of course the shortest. Thus the section by Whitcombe Pass, which follows the beds of the most important rivers of each coast, namely, the Rakaia on the eastern, and the Hokitika on the western slopes of our Alps, gives us a clear insight into the fall of both rivers, and shows the remarkable difference between the length of their courses and their gradients. Thus, whilst the Rakaia, which is 85 miles long, has

* These distances have been measured on the map of the province, and as they pass very often over ground which has only been sketched in, it is almost needless to say that they are only fair approximations. Since these sections were constructed by me, the road by Arthur Pass, from Christchurch to the mouth of the Arahura, has been carefully levelled and measured by the Public Works Department, with the following result:—

Altitude of Pass in central chain 3013 feet.
 Total length 141 miles 78 chains.
 Length from summit of Pass to east coast 94 „ 6 „
 Length from summit of Pass to west coast 47 „ 72 „

† Two good sets of observations, obtained during my last journey on March 31, 1866, give a somewhat different result for this the highest available pass in the province, namely 4752 feet, or 105 feet higher than the altitude calculated from a single observation in November, 1865. I think that the result obtained at the latest date claims more correctness, for not only had I a double set of observations taken during fine weather at the regular hours observed at the Christchurch meteorological station, but I had also the advantage of a further check for my calculations by taking into account the observations taken at the Hokitika meteorological station, which did not exist when I travelled over this pass in the beginning of last spring.

an average fall of only $39\frac{1}{2}$ feet per mile from the Ramsay Glacier its source to the sea, the Hokitika, 40 miles long, has from the Sale Glacier to the west coast a fall of $104\frac{1}{2}$ feet in the mile. This difference is still more remarkable if we compare the course of the Waitaki, which is 117 miles in length from the terminal face of the great Tasman Glacier (2772 feet), and is the longest and largest river of our province, with the opposite Waiau River, which is only 12 miles from the terminal face of the Francis Joseph Glacier (708 feet). This gives $23\frac{3}{4}$ feet fall for the eastern, and $57\frac{1}{2}$ feet for the western river. The latter would have of course a much greater fall, considering the close proximity of the summit of the central chain to the coast, did not the Francis Joseph Glacier descend to such a remarkably low position.

A few words of explanation to each line of section will not be superfluous, as not only will it assist the examination, but as there are many peculiar physical features in each route which these sections cannot entirely convey, and to which I draw attention.

Otira Section.—The road ascends the Canterbury plains to near the junction of the Kowai with the Waimakariri, but instead of crossing that tributary and following the main river through the gorge on the northern slopes of the Mount Torlesse range, which presents very many obstacles, the road ascends the Kowai to the junction of the two main branches, and so brings us to Porter Pass, which separates the Mount Torlesse from the Thirteen-mile-bush range. According to my altitude observations Porter Pass is higher than Arthur Pass, and thus we find that the approaches lead over higher ground than in the pass across the central chain itself.

From here to the Craigieburn Saddle we find ourselves in a tertiary basin, traversed by several tributaries of the Waimakariri, which descend from the Craigieburn range. This bleak chain of mountains, about 7000 feet high, forms the watershed between the former river and the Rakaia. Descending more than 700 feet, we reach Lake Pearson and the glacialized country of the Waimakariri, where the hills are remarkably rounded, and large open tracts, now covered by moraine accumulations or alluvium, the former bed of the huge postpliocene Waimakariri Glacier, are traversed.

The road reaches the valley of the Waimakariri after crossing the River Cass, and runs for several miles along the slopes of the outrunning spurs on its southern banks. It afterwards descends into the river-bed, and crosses a succession of fans of southern tributaries till opposite the junction of the Bealey,

where the road leads across the main river and follows the latter tributary to Arthur Pass.

When examining the Alpine passes of this province, I observed that invariably a glacier descended on each side, going in a different direction; and although near some of them the glaciers have retreated in the ranges, on both sides, several thousand feet above the present watershed, the glacier-shelves and remains of lateral moraines, with which the surrounding mountain-sides are covered, show at once that much larger glaciers existed formerly in those localities.

These extensive ice-masses have, without doubt, planed the central chain on both slopes and in opposite directions, till the ridge has been worn down to its present form. Dr. Hector made the same observation in the Otago Alps; and thus we observe again how nature, to obtain gigantic ends, uses very simple but effectual means for their accomplishment. The same remark applies equally to Arthur Pass, where remains of moraines going in opposite directions, and the course of the present streams by which the Bealey and Otira rivers are formed, give additional confirmation to such a theory.

I may here draw attention to the peculiarly slight ascent of the Bealey as compared with that on the Otira side, which is characteristic of every portion of our central chain; although in this instance we must not lose sight of the fact that the Otira is a much larger river than the Bealey, and that, consequently, the power to excavate its bed deeper was so much greater.

After a few miles, the gorge-like character of the Otira changes, and we emerge into a large valley, which has all the features peculiar to our shingle rivers, and which leads us into the large open valley of the Teramakau. Instead of following that river to the ocean, the road 24 miles above its mouth once more descends the low western slopes of the central chain, here consisting of great gold-drift, reposing without doubt on tertiary beds, and descends again by the Kawhaka Creek into the bed of the Arahura, bringing us thus to the west coast.

Harper Pass, between the head-waters of the Hurunui and Teramakau, is the second pass which from its low position and easy access recommends itself to our attention. It was the only one in use by the natives of the province, and was therefore known and traversed for many years.

An excellent dray-road brings us to the Waitohi Gorge, where a bridle-track begins and leads across the Waitohi Saddle, 1858 feet high, before we reach the valley of the Hurunui. This saddle, like that over Porter Pass on the Otira Road, could have been avoided by following the main stream from the

Hurunui Plains; but as the gorge-like character of its bed would have offered serious impediments, only to be overcome by very great outlay, this saddle was preferred as a natural road. Even now, when the bridle-track reaches the valley of the Hurunui, it leads along the precipitous sides of the southern ranges, which are remarkably bold and rugged, as far as the junction of the Southern Hurunui.

The track, when it reaches the lake regions, instead of following the main river to Lake Sumner, ascends a high shingle terrace and brings us to Lake Taylor, which lies 251 feet higher than the principal lake, and from which we descend by Lake Catherine in one of those remarkable glacier-channels into the bed of the Hurunui, a little way above its fall into Lake Sumner. This bed has, like all our rivers above the Alpine lakes, a straight valley to its source, and in which it meanders in many branches. The road follows this river-bed, beautifully wooded on both sides, to the foot of the pass, and an easy ascent of about 300 feet brings us to the summit. Like Arthur Pass, it is on both approaches and on the mountain sides covered with sub-alpine vegetation, whilst the saddle proper is formed by swampy ground with small waterholes at different levels and with outlets in opposite directions. The descent into the bed of the Teramakan is far more rapid than the ascent by the waters of the Hurunui.

At the same time the source-branches are far more important, and form, after having descended 1500 feet in a few miles, a river much larger than the Hurunui on the opposite side. This western valley has a straight course, and can, even without a road and when the water is not high, be followed with horses to the west coast by swimming across at a few localities in the gorges below the junction of the Waimea where the river breaks through the low tertiary ranges.

The North-Rakaia Route, by Browning Pass, does not, with the exception of the pass itself, present any serious difficulties. The road follows the Canterbury Plains to the moraine accumulations beginning near the gorge of the Rakaia, now mostly concealed under alluvial beds, to Fighting Hill, when it follows an old course of the Rakaia, across several moraines.

Reaching the terraces of the Acheron, the road descends several hundred feet to the bed of that tributary of the Rakaia, and ascends again considerably till it reaches the moraines lying above Lake Coleridge. A descent of about 100 feet brings us to the south-eastern corner of that fine sheet of water, now the head of the lake. In my section I have followed the old road by the Lake Selfe depression, running between low iceworn

hills across several small tributaries of Lake Coleridge, and after having reached the former lake followed its outlet to the Harper, a tributary of the Rakaia.

Crossing the Harper a few miles above its junction with the Wilberforce, the road again ascends, crosses the numerous fans which unite the isolated ice-worn Scott hills to the main range, and descends above those *roches moutonnées* into the bed of the Wilberforce. Here the road crosses the stream, following afterwards along the base of the Cascade Range over good ground to the junction of the Stewart River, which is the principal branch of the Wilberforce.

Having crossed that river (Stewart) we travel by a good track to the southern base of Browning Pass, which rises about 1500 feet above the river. I may here observe that I was obliged to exaggerate the vertical scale in the sections, as it would have been impossible to show the details of these routes otherwise.

The steep slopes forming Browning Pass look, therefore, in this section almost vertical, and form a striking feature when compared with the other passes, the slopes of which are of a much easier gradient.

Having ascended the southern face of Browning Pass, passed along the small isolated lake situated on its summit, and crossed the ice-worn hills of which the summit is formed, we descend by the steep northern slopes into the bed of the Arahura, which, above the junction of the Harman, is so open that the traveller can advance rapidly by crossing and re-crossing; but immediately above that junction and for several miles below the river is confined between perpendicular cliffs, often several hundred feet high, which with little interruption continue till the river reaches the west-coast plains. The track, therefore, after passing the Harman Stream, leads along the eastern shoulder of Mount Sale instead of following the Arahura, and crosses a low saddle (the so-called Wooded Saddle), which brings us to the headwaters of the River Styx, one of the source-branches of the Hokitika. This stream has a remarkably straight course, and brings us into the west-coast plains.

Whitcombe Pass is another interesting pass. The road to it, so far as the south-eastern end of Lake Coleridge, is the same as the Wilberforce Road: here it diverges and follows the bank of the Rakaia to above its junction with the Wilberforce.

Crossing the Wilberforce near its junction with the Rakaia proper, the road leads along the slopes of Mount Algidas to the junction of the Whitcombe, the river-bed being too swampy to follow. Having crossed the Mathias at its junction, the road continues for about seven miles over a large flat on the northern

side of the river, where the stream sets against its banks, which are covered with dense vegetation and rise nearly perpendicularly above the water for a considerable altitude. The traveller has, therefore, to cross to the southern side, and to follow a grassy flat along the Arrowsmith range.

Having arrived at the point which projects most into the river-bed from that range, the last crossing is effected; and after travelling for a few miles over shingle-beds, we reach the junction of the Whitcombe Pass Stream with the Rakaia. From here the remarkable opening through the Southern Alps is clearly defined. Following then the valley of this true mountain torrent over huge blocks of rocks and through dense Alpine vegetation, and crossing several large streams rushing down the steep mountains from several glaciers, we reach, after having ascended a *débris* wall stretching across the valley, the summit of the pass, when the interesting phenomenon of two glaciers going in different directions is still visible.

On the Sale Glacier the main source of the River Hokitika reaches still across the valley; and if the Martin's Glacier, the main source of the Whitcombe Pass Stream, would only advance a few hundred yards, the moraines of both, and perhaps the ice-masses, would meet on the summit of the pass, although descending in different directions. The descent towards the west coast is more rapid, particularly for the first 400 to 500 feet.

For about ten miles on the western side the road follows the straight shingle valley of the river, which afterwards enters the wooded west-coast ranges, forming a succession of gorges, with rapids and waterfalls.

Jacob Louper, the surviving companion of the late Mr. H. Whitcombe, Government surveyor, has given us a vivid description of this portion of the route in a report to the Government. It is partly unknown to me, as I ascended the Hokitika River for only 30 miles from the sea-coast.

Haast Pass.—There remains only that pass to which my name has been given, situated near the head of Lake Wanaka, and which lies so remarkably low, considering the altitude of the Alpine ranges on both sides. On the section I have shown the road I travelled by, which is that generally used by travellers in this province. By it two passes of greater elevation than the principal pass across the central chain have to be crossed, namely, Burke Pass, leading from the headwaters of the Opihi into the Mackenzie Plains, or upper valley of the Waitaki, and thence by Lindis Pass into the valley of the Molyneux. Both could, of course, be avoided by following along the valley of that

latter important river; but as my object was principally to show the comparative value of each route to the province of Canterbury, I could not abandon the direct road leading to Lake Wanaka. My section shows the road which crosses these two passes leading thence to Lake Wanaka, and along the shores of that lake to Messrs. Stewart and Kinrus's station. From thence we proceed by water to the head of the lake, as there is much difficulty in travelling with horses along the shores of the upper portion of the lake, the country being very rough in many places. Thence to Haast Pass the road follows the valley of the Makarora and its tributaries by a very easy gradient, and then falls more rapidly for about 10 miles to the junction of the Burke with the Haast, when again the natural fall of the valley to the sea offers a remarkably fine highway between the two coasts.

In former publications which I had the honour to lay before the Society, I have described this road at length, so I need give no more details about it now.

*On the Value of Barometric Observations, taken on a rapid
Journey, for calculating Altitudes.*

Since the altitude sections and the comparative diagrams were prepared, and the foregoing remarks were written, I have, through the courtesy of Mr. E. Dobson, the provincial engineer, obtained possession of the results, obtained by means of the spirit-level, for the whole Otira or Arthur Pass Road, which are personally of the greatest interest to me, besides possessing a high intrinsic value. Not only is there a very perfect altitude section of that important road thus obtained, uniting the agricultural and pastoral districts of the eastern side with the western goldfields, but it gives me also a very welcome opportunity to check my own barometric observations, calculated six months previously.

These altitudes, obtained by the Public Works Department, may, of course, be relied upon, as they have been twice checked, and the difference was found to be only a few inches.

Mr. Dobson has kindly allowed me to publish these spirit-level altitudes, which I do the more readily, as it gives me an opportunity to compare them in the following table with my own, obtained with three good aneroid barometers, and to which I beg to draw the attention of geographers:—

TABLE of ALTITUDES of the Road by ARTHUR PASS, across the Province of Canterbury, New Zealand, as obtained by the following observers.

Places of Observations.	Dr T. Haast's Barometric Altitudes, Nov. 18, 1865.	Spirit Level Altitudes of Public Works Department, April, May, June, July, 1866.
	feet.	feet.
Cook's Accommodation House	217	228·00
White's Accommodation House	623	631·23
Southern base of Little Racecourse Hill	995	979·39
McRae's Accommodation House (formerly Willis's)	1327	1273·54
Southern bank of River Kowai	1387	1424·47
Centre of bed of River Kowai	1342	1393·62
Riddle's Accommodation House, foot of Porter Pass	2091	2060·00
Summit of Porter Pass	3234	3097·00
Lake Lyndon (high-water line)	2814	2743·00
Springs, sources of River Porter	2609	2535·00
River bed of Porter, where road crosses	2270	2266·00
Summit of Terrace on its western side	2473	2491·00
Bed of River Thomas	2214	2197·6
Accommodation House near Mr. Eny's Station* (stable of Cobb and Co.)	2418	2374·00
Top of Terrace of Broken River, eastern side ..	2413	2390·00
Bed of Broken River	2163	2094·00
Top of Terrace on its western side	2386	2350·00
Road near summit of Parapet Rock	2760	2750·00
Bed of small creek near Shanty	2614	2583·00
Top of Craigieburn Saddle	2843†	2619·00
Lake Pearson	2095	2085·00
Road crossing River Cass	1879	1874·00
Saddle between Cass and Waimakariri (Goldney Saddle)	1938	1929·00
Bed of Waimakariri, between the two cuttings ..	1863	1808·00
Crossing of Waimakariri	2065	2044·00
Bealey Township (Police reserve)	2155	2130·00
Southern foot of Arthur Pass (Smith's Camp) ..	2534	2497·00
Arthur Pass (highest summit)	3038	3013·00
Southern foot of moraine	2697	2666·00
Summit of moraine	2865	2825·00
River bed of Otira, first bridge	2026	2035·00
Junction of two branches of Otira near the stock- yard	1449	1450·00
Bed of Teramakau near junction of the Otira, where the road joins the main river	769	731·00
Western bank of River Taipo, near junction of Teramakau	356	355·00
Waimea, where the road leaves the Teramakau ..	148	168·00
Foot of Terrace	121	159·00
Summit of highest Terrace	647	652·00
McClintock's store near Kawhaka Creek	410	422·00
Junction of Kawhaka with Arahura	145	104·00

* In my report this position was erroneously set down at 2548 feet above the sea, which is the true altitude of Mr. Eny's homestead, which lies close to the accommodation house.

† Without doubt an error in the readings, as the observations on both sides taken an hour before and afterwards, agree very closely with the spirit-level.

It will be seen from these tables that my altitudes were in general a little too high. To produce this the difference in the state of the atmosphere at the meteorological station near the sea-coast, and at the same time on or near the summit of the passes in the interior, may have had some influence on the readings of my instruments, not to speak of minor index errors.

The table shows thus once more convincingly that although mathematical correctness cannot be claimed for altitudes calculated from barometric observations, they are nevertheless sufficiently accurate for all practical purposes. And every observer must rejoice that even single observations, when carefully taken, possess more intrinsic value than is generally allowed to them.

I am afraid that these few observations will not be of sufficient interest to warrant my laying them before the Society, which receives such valuable and instructive papers from all parts of the world; but my desire to make geographers acquainted with some of the results obtained lately by me when enquiring into the physical geography of some portion of this beautiful island will, I trust, be sufficient excuse for my having done so.

Christchurch, December 27, 1866.

XVII.—*On the Subterranean Supply of Water in Beloochistan and the Hill Districts of Western Sind.* By J. W. BARNES, Esq., C.E., F.R.G.S., late of H.M. Bombay Public Works Department.

HAVING resided the greater portion of the period since 1845 in Sind, where, from the scarcity of rain, water, and above all running water, is the “*summum bonum*” of the land, and where its economical application to irrigational purposes formed the nature of my duties on the Staff of Colonel (then Captain) Fife, our great hydraulic engineer, I had long entertained the idea that subterranean water existed in certain localities in the hills, capable of overflowing through artesian borings if they were made, and in 1865-6 I determined, after a critical examination of the hills bordering Sind, to give this mode of obtaining water a trial.

The place selected for my labours was distant about 8 miles north-east of Kurrachee, and I had the satisfaction after some weeks’ labour of piercing the first water-bearing stratum, when the water rushed up and overflowed the surface, continuing, without intermission, to flow to this day.

The water is of a temperature of 85°, and as the stratum in which it is found is a saline aluminous shale, it is, from per-